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B. S. Thesis

Web-Based Gym Equipment Management & Reservation System

by

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A Project Presented

by

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Abstract

This thesis investigates the development and implementation of a Web-Based Gym Equipment Reservation and Management System designed to modernize and optimize traditional gym management methods. Current manual equipment management processes, despite being widely used, are often time-consuming, error-prone, and inefficient. This research presents an automated solution that effectively addresses these limitations by utilizing QR code technology and real-time tracking.

The proposed system has been developed using Python Flask, a robust and scalable web application framework. Flask serves as the foundation for backend development, ensuring seamless functionality and efficient data management throughout the system. QR code capabilities have been integrated to provide fast and accurate processing for gym entry/exit tracking and equipment reservations. The system automates the process by eliminating the need for traditional manual methods.

The primary objective of this thesis is to provide an efficient, accurate, and user-friendly equipment management system specifically designed for gym needs. The system's main goal is to increase training efficiency by reducing waiting times in the gym. By minimizing manual intervention, the system reduces the risk of human error and significantly accelerates the equipment reservation process.

The system also enables gym efficiency optimization by providing equipment usage statistics to admin users. Managers can make strategic decisions by seeing which equipment is used how frequently. For example, they can reduce queue waiting times by increasing the number of heavily used equipment or replace underutilized equipment with more popular ones. This analytical approach ensures more effective use of gym resources.

Additionally, it saves time for both managers and users by ensuring secure and accurate storage of reservation data, while increasing reliability.

Performance evaluations of the system demonstrate high accuracy rates in QR code recognition and reservation management under various conditions. These results validate the system's reliability and effectiveness in real-world applications. Furthermore, the integration of modern web technologies provides an intuitive and accessible, user-friendly interface that supports users with varying levels of technical expertise.

In conclusion, the Web-Based Gym Equipment Reservation and Management System developed in this thesis offers significant improvements over traditional gym management methods. It provides an efficient, accurate, and user-friendly solution that saves time and guarantees data security.

Acknowledgements

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I would also like to express my deep gratitude to my family for their unwavering love, support, and encouragement throughout my entire academic journey. Their faith in me, even during moments of doubt, served as a constant source of motivation. They were a pillar of strength and provided the emotional support and stability necessary to pursue my educational goals.

I thank Işık University for providing the opportunity to use and test the school gymnasium within the scope of this project. This experience was invaluable for testing and developing the system under real conditions.

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Chapter 1 Introduction

1.1 Overview

Equipment management and user experience in gyms has become one of the most critical areas of the modern fitness industry. In traditional gyms, users must physically check to see if their desired equipment is available, and when equipment is occupied, they have to ask the person using it how many more minutes or sets they have left to find out when it will be free. This situation creates both a socially uncomfortable and inefficient process.

This thesis focuses on the development of a Web-Based Gym Equipment Reservation and Management System designed to optimize gym users' equipment usage and minimize waiting times. The system combines QR code technology with real-time tracking to provide users with instant information about equipment status and enable them to plan for future usage.

The proposed system has been developed using the Python Flask web framework and offers comprehensive features to users. Users can check in by scanning a QR code upon entering the gym, view the real-time status of available equipment, and learn when desired equipment will be free if it is currently occupied. The system also provides queue management functionality, allowing users to join queues for equipment and learn estimated usage times.

One of the system's most important features is enabling users to efficiently utilize their waiting times. A user who joins a queue for equipment can increase their workout efficiency by using other equipment instead of wasting their waiting time. Thanks to the real-time notification system, users using equipment are automatically warned before their reservation times expire and receive silent, audible, or vibrating notifications.

The system also offers users the opportunity to plan before going to the gym. Users can determine optimal workout times by viewing real-time gym occupancy rates. This feature provides great convenience in the decision-making process, especially before going to the gym during peak hours.

The analytics dashboard provided for admin users offers the ability to view equipment usage statistics in detail. This feature allows gym managers to make strategic decisions by analyzing

which equipment is used how frequently. Resource optimization decisions such as increasing the number of heavily used equipment or replacing underutilized equipment can be made with a data-driven approach.

This introduction section summarizes the motivations behind the system, the goals it aims to achieve, and the key features of the developed solution. Subsequent sections will comprehensively address system architecture, technologies used, implementation details, and performance evaluations. The system aims to improve gym users' training experience while providing managers with the necessary tools to increase operational efficiency.

1.2 Motivation

Equipment usage and management in traditional gyms creates various challenges for both users and managers. These challenges negatively affect the modern gym experience, reducing user satisfaction and leading to operational inefficiencies.

Problems Experienced from User Perspective:

Gym users face many significant problems in existing systems. The most fundamental problem is the obligation to physically check whether the desired equipment is available. When equipment is occupied, users must ask the person using it how many more minutes they will use it or how many more sets they have left to find out when it will be free. This situation is both socially uncomfortable and problematic in terms of obtaining reliable information.

In situations of uncertainty, users often must wait for equipment to become available, which leads to inefficient use of workout time. When searching for alternative equipment, it is necessary to walk around the gym to see which equipment is available. This situation leads to frustration and time loss, especially during peak hours.

Operational Management Challenges:

From the perspective of gym managers, the lack of access to equipment usage data is a critical problem. There is no systematic data to analyze which equipment is used how frequently, at what times congestion occurs, and how efficiently resources are utilized. This situation causes equipment investment, capacity planning, and operational optimization decisions to be made based on estimation and experience.

Additionally, tracking gym occupancy rates and providing this information to users is not possible with existing systems. This situation causes users to come to the gym during peak hours and experience waiting.

Need for Efficiency Enhancement:

The automatic equipment reservation and management system developed to solve these problems aims to achieve the following main objectives: enabling users to view equipment status in real-time and plan usage, optimizing waiting time by joining the queue system when equipment is occupied, efficient utilization of waiting periods by using other equipment, providing detailed usage analytics for managers to make data-driven decisions, real-time tracking of gym occupancy rates and presenting them to users, and improving user experience with automatic notification system.

The system developed with these motivations aims to significantly increase both user experience and operational efficiency by eliminating inefficiencies in traditional gym operations.

1.3 Contributions

This project makes significant contributions to the field of gym management through both technical and practical developments. The following summarizes the main contributions:

1. Technical Contributions:

Implementation of Real-Time QR Code-Based Reservation System: The core of this system is the integration of a sophisticated reservation module using unique QR codes for each equipment. This innovative technology allows users to access the reservation screen directly by scanning QR codes on equipment. Users can make reservations quickly and easily after entering the desired usage time. This implementation required careful selection and optimization of web-based QR code reader technologies to achieve reliable QR code recognition and a seamless reservation experience.

Integration with Web Technologies for Accessibility: The project leverages web technologies to ensure the system is widely accessible and user-friendly. This web-based

interface allows authorized personnel to manage and access reservation records from any location with internet connectivity, overcoming the limitations of traditional, localized systems.

Development of Secure Authentication System: A critical component of the project is the implementation of a robust and secure authentication system. This system maintains data integrity and restricts access to authorized users only. Security protocols have been carefully designed and implemented to prevent unauthorized access to sensitive information and ensure data privacy and confidentiality.

Creation of Efficient Database Structure: To effectively manage and store the large amount of reservation data generated by the system, a carefully designed and efficient database structure has been implemented. The database is optimized for both fast data retrieval and scalability, allowing the system to effectively handle large datasets and increasing numbers of users.

2. Practical Contributions:

Increasing Efficiency in Gym Operations: The system significantly increases operational efficiency by enabling gym managers to optimize time and resource usage.

Improving User Experience: User-friendly design and automated processes create a better experience for gym users.

Ensuring Data Reliability: The automated system provides more reliable and accurate data collection by eliminating human error.

1.4 Outline of the Project

This thesis presents a comprehensive investigation of the development and implementation of an automated gym management system. The document is structured in seven chapters:

Chapter 1: Introduction: This chapter sets the stage by introducing the general project concept, summarizing problems with existing traditional gym systems, and defining the aims and objectives of this project.

Chapter 2: Literature Review: This chapter examines relevant previous research and existing technologies in the field of gym management and QR code recognition. It provides contextual background and highlights the gaps this project aims to address.

Chapter 3: System Analysis and Design: This chapter delves into detailed analysis of system requirements and architectural design of the automated gym management system. It explains components, functionalities, and overall system workflow.

Chapter 4: Technologies and Tools: This chapter provides a detailed overview of specific technologies, software, and tools used throughout the development process, including explanations of how they were selected and utilized.

Chapter 5: Implementation: This chapter details the practical steps involved in implementing the automated system, including programming, coding, database integration, and user interface development phases.

Chapter 6: Results and Discussion: This chapter presents results obtained from the implemented system, including performance data, test results, and analysis of system effectiveness, comparing with traditional methods.

Chapter 7: Conclusion and Future Recommendations: This chapter summarizes the key findings of the project, discusses system limitations, and offers suggestions for future research and improvements to the existing system.

Chapter 2 Literature Review

2.1 Overview

The proposed Gym Equipment Reservation and Management System aims to optimize equipment management in gyms. The system will allow members to easily reserve equipment, track real-time usage, and implement QR code-based equipment usage monitoring. This system will be developed using the Python Flask framework with SQLite database for data persistence. The following literature review examines relevant research that supports the technological and conceptual foundations of this project.

2.2 Web Development Technologies

Modern web application development requires selecting appropriate technologies that enable efficient development and deployment. Patkar et al. noted in their study that Python stands out among web programming languages due to its coding simplicity and ease of learning [1].

The selection of Flask as the web framework for this project is supported by the research of Vyshnavi and Malik. The researchers emphasized that Flask is a suitable platform for developing dynamic web applications using Python. Their study demonstrates that Flask provides the necessary technological foundation to meet the requirements of modern web applications [2]. This view is further strengthened by Rybárová's thesis. Rybárová's implementation has shown that Flask is suitable for simple web applications with management capabilities that will be necessary for a gym equipment reservation system [3].

The selection of Flask as a web framework is also supported by Palma Comas's implementation. The researcher stated that Flask is a Python framework that allows creating and hosting web pages with minimal code. Palma Comas also highlighted the simplicity of the Flask installation process. Flask can be installed on the machine that will serve as the server using simple commands and run with a configuration where basic parameters can be defined [22].

Khapre and Kandelkar noted that gym management systems help managers complete tasks faster while reducing complexity and time usage. Their implementation using Java and MySQL

demonstrates the effectiveness of database-based approaches for gym management, but our application will use Python and Flask for greater development simplicity [13].

2.3 Benefits of Web Applications

The proposed gym management system takes advantage of the benefits of web applications compared to traditional software. Patkar et al. stated in their study that web applications do not require publication and distribution costs. They also emphasized that these applications do not need to be installed separately on each client's computer but instead can be placed on a central server and accessed by numerous clients [1].

Additionally, Patkar et al. also highlighted the advantages of centralized management of web applications. Thanks to the centralized management of a web application, application updates and data backups can be performed more easily [1].

Tchórzewski et al. performed an analysis of a web application supporting gym management designed in terms of control and systems theory. Their research demonstrated the value of systems theory in designing robust gym management applications, especially for subsystems such as diet creation. The researchers determined that web application models achieved high accuracy, showing that carefully designed web applications can effectively model and manage complex gym operations [12].

2.4 Reservation Systems in Educational and Fitness Contexts

Toderick et al. developed a system that allows students to reserve IT equipment over the internet. This system enables students to do their hands-on exercises at their convenience, save configurations, and automatically prepare the equipment for the next user. This reservation system developed for IT equipment demonstrates the feasibility and benefits of implementing similar systems in other contexts, including gym equipment management [4].

More directly relevant to the proposed project, Ebrahimi et al. developed a system they called "GymScheduler." This system aims to reduce waiting times for gym equipment during busy

hours and offers users the opportunity to reserve different types of equipment for a specific period. Their system aims to reduce waiting times and help users adhere to their exercise programs, which aligns with the goals of the proposed gym equipment reservation system. User study results showed that participants preferred to use the website and have the opportunity to reserve equipment in the gym, validating user demand for such systems [5].

Jia Mei and Wahid developed a web-based Reservation Management System for a farm. This study showed that reservation systems can facilitate reservation services and solve problems such as manual ticket entry, staff shortages, and irregular reservation management. Their implementation revealed that such systems can reduce the need for manpower and increase business volume [9].

Ahmad et al. developed the "Sports Facility Reservation System (SFRS)" addressing the problem of unequal use of university sports facilities. The system implemented basic functions such as user registration and login, date selection, reserving sports facilities, and database creation. Their evaluation showed that despite some weaknesses, SFRS was able to fulfill its purpose and objectives, providing an example of a successful sports facility reservation system [18].

Lee et al. designed and implemented an exercise machine reservation system that allows users to reserve fitness equipment using NFC-based smart wristbands. Their system showed that such reservations can help users use equipment comfortably even during busy times. They also noted benefits for facility managers who can achieve cost savings through efficient facility management and offer customized member management, which aligns with the expected benefits from our proposed system [17].

2.5 Integrated Monitoring of Gym Capacity

One of the core features of our proposed system is the ability to monitor the current capacity of the gym, which directly addresses a need identified by Palma Comas. In his study, he emphasizes the importance of providing users with information about facility conditions, including capacity [22].

This feature complements the findings of Badriah and Shandy. The researchers noted that QR code-based systems can help administrators monitor the number of member entries, remaining attendance quota, and attendance duration [21].

2.6 Equipment Usage Optimization and Queue Problems

Girginer and Şahin investigated queue problems that occur during the use of sports equipment in a fitness center using the simulation method. Their research identified factors affecting capacity problems and developed a simulation model for solving the problem. The researchers concluded that existing capacities could be optimized without creating new channels by implementing some marketing strategies [16].

Çaylı et al. conducted a study on "Sports Equipment Usage Prediction for Efficient Gym Management" using 2013-2017 data to predict 2018 usage patterns. Their system produced annual, monthly, daily, and hourly usage predictions and presented these analyses with graphs in a simple, understandable manner [15].

Turak Kaplan et al. examined current problems in sports business management and solution proposals. Their qualitative research with sports business managers determined that people receiving sports services mostly want to participate in sports businesses with experienced and knowledgeable trainers. They also noted that managers face challenges related to member expectations and health services and address these with competition and advertising elements [14].

2.7 QR Code Technology Implementation

A key feature of the proposed system is QR code-based equipment tracking. Singh emphasizes that the QR code management system significantly reduces human labor and does not require additional funding or resources [6].

Kaushik et al. provided a comprehensive understanding of the basic principles of QR code technology. These principles include the structure of QR codes, error correction capabilities, and applications in various sectors. The researchers emphasized that Python serves as a powerful, flexible, and user-friendly tool for creating QR codes [7].

Naga Raju et al. note that QR codes are frequently used for tracking information about products in a supply chain. This application can be adapted to monitor gym equipment usage. They also noted that every new smartphone comes with a built-in QR code reader [8].

The implementation of QR codes in management systems is further validated by Yadav et al. The researchers developed a "QR Code based Android Application System" for reservations. They emphasized that QR codes can contain data about tickets and passenger information and can be used for identity verification by staff [10].

Karthik et al. developed a QR Code Based Attendance Management System. In this system, students record their attendance with ID cards containing unique QR codes. The researchers emphasized that the system distinguishes between valid and invalid QR codes and ensures accurate attendance recording [20].

Din and Fazla demonstrated the integration of QR code implementation with a web-based and mobile application for library management system. Their study revealed that QR codes enable quick data retrieval at minimal cost. The researchers noted that advantages such as easy finding of physical locations, quick retrieval of information, and prevention of unnecessary time waste are directly applicable to the expected benefits of applying QR codes to the gym equipment management system [11].

Badriah and Shandy examined the benefits of a QR code-based system for membership management in gyms. The researchers noted that users can easily check in by simply scanning a QR code linked to their membership data. They emphasized that this system not only facilitates the attendance process but also helps administrators monitor the number of member entries, remaining attendance quota, and attendance duration [21].

2.8 Operational Efficiency of QR Code-Based Systems in Gyms

Badriah and Shandy examined the effects of QR code-based entry system on operational efficiency in gyms. The researchers emphasized that the system, in addition to facilitating the

attendance process, provides administrators with monitoring capabilities regarding the number of member entries, remaining attendance quota, and attendance duration [21].

These results are also consistent with the findings of Lee et al. The researchers noted that gym managers can achieve cost savings through efficient facility management and offer personalized member management [17]. The integration of QR code technology, as noted by Din and Fazla, can enhance the effectiveness of the gym equipment management system by providing quick data access at low cost [11].

2.9 Energy Expenditure in Gym Equipment Usage

Understanding energy expenditure during gym equipment usage is crucial for optimizing workout efficiency and providing accurate caloric burn estimates. Lafortuna et al. conducted a comprehensive study examining energy costs of rhythmic exercise with different equipment exercising upper and lower limb muscle groups in normal-weight and severely obese individuals. Their research demonstrated that net energy cost (Enet) increased significantly with frequency of movement (FOM) for all equipment types in both normal-weight and obese subjects [23].

The study revealed significant differences in energy expenditure between equipment types. For high-frequency exercises (80-90 movements/minute), upper limb equipment showed varying energy demands: Chest/Back exercises required 0.86 l/min for normal-weight males versus 1.12 l/min for obese males, while Biceps/Triceps exercises showed similar patterns with 0.98 l/min versus 1.33 l/min respectively. Lower limb exercises demonstrated higher energy costs, with Leg Press being the most demanding at 1.25 l/min for normal-weight males and 2.00 l/min for obese males [23].

The research also highlighted gender differences in energy expenditure patterns. Female subjects generally showed lower absolute energy consumption but higher relative intensities compared to males. For instance, normal-weight females consumed 0.76 l/min during Chest/Back exercises compared to 1.03 l/min for obese females, demonstrating the impact of body composition on exercise energy costs [23].

Complementing these findings, Brown et al. compared energy expenditure between treadmill and elliptical exercise modalities at self-selected exercise intensities. Their study found that

when subjects exercised at the same perceived exertion level (RPE 12-13), energy expenditure was similar between modalities despite differences in heart rate response. Treadmill exercise resulted in 150.9 ± 11.0 kcal for males and 117.9 ± 9.2 kcal for females during 15-minute sessions, while elliptical exercise showed slightly higher values at 171.9 ± 10.5 kcal for males and 132.3 ± 8.2 kcal for females [24].

These findings provide essential baseline data for implementing accurate caloric expenditure calculations in gym equipment reservation systems, enabling users to make informed decisions about equipment selection based on their fitness goals and energy expenditure targets.

2.10 Data Persistence and Framework Selection

For the database component, the proposed system will use SQLite. This choice aligns with the views of Patkar et al. regarding data persistence options [1].

Gaffney et al. noted that SQLite has become the most widely used database engine and is found in almost every smartphone, computer, web browser, television, and automobile. The researchers emphasized that the possible reasons for SQLite's popularity include its in-process design, independent code base, comprehensive test package, and cross-platform file format. They also noted that while SQLite supports complex analytical queries, it is primarily designed for fast online transaction processing (OLTP) [19].

Regarding framework selection, Patkar et al. recommend that a web framework providing WSGI support should be preferred. The researchers noted that this support facilitates the deployment of an application [1].

Chapter 3 System Analysis and Design

3.1 Overview

This chapter details the comprehensive analysis and design process of the Web-Based Gym Equipment Reservation and Management System. In the system analysis phase, user needs and system requirements were determined, defining functional and technical requirements. In the design phase, system architecture, database structure, and user interface designs that would meet these requirements were developed.

The fundamental purpose of the system is to enable gym users to make equipment reservations, view real-time equipment status, and optimize waiting times. At the same time, it aims to improve gym operations by providing equipment usage analytics and operational efficiency tools to managers.

The design decisions presented in this chapter have been made considering modern web technologies and user experience principles. The system architecture has been planned to meet scalability, security, and performance criteria.

3.2 System Requirements

System requirements have been categorized as functional and technical requirements to clearly define the intended behaviors and necessary performance characteristics of the system.

3.2.1 Functional Requirements

User Authentication: The system must allow users with Işık University email addresses (@isik.edu.tr or @isikun.edu.tr) to securely register accounts by providing name, surname, email, and password information. Registered users must then be able to securely log in using their email and password credentials. The system must maintain user login status using Flask-Login and implement robust session management to prevent unauthorized access during sessions. All user passwords must be encrypted using hash algorithms with the Werkzeug security library before being stored in the database and securely maintained. The system must

distinguish between admin and normal user roles and restrict access to admin features to authorized users only.

Gym Entry/Exit Management: Students must be able to scan QR codes to enter the gym. The system must automatically record entry time and update gym occupancy rate. When exiting, students must scan the exit QR code, the system must automatically record exit time and terminate active reservations. The system must calculate real-time gym occupancy rate and display it to users.

Equipment Reservation Features: The system must track the instant status of all equipment (available, in use, out of order). Students must be able to reserve available equipment and specify reservation duration (between 5-120 minutes). When equipment is occupied, students must be able to join queues, and the system must provide automatic queue management. Students must be able to cancel their active reservations or reduce their duration.

Notification System: The system must warn users 1 minute before reservation completion. Must use browser notifications, audio alerts, and visual modals. Must provide vibration support on Android and iOS devices.

Reporting: Display completed reservation history for individual users, total workout time, total session count, and most frequently used equipment information grouped by date. Equipment usage statistics for administrators, analysis of total session count, total usage hours, and average usage durations based on weekly/monthly/yearly periods. Calculation and display of real-time gym occupancy rate, maximum capacity control. Ability to filter users' workout history by date ranges (today, this week, this month, all time) and make custom date selections.

3.2.2 Technical Requirements

System Performance: The system must respond to user requests (page loads and form submissions) within 2 seconds. The system must be able to handle multiple users simultaneously without significant performance degradation. The system must be able to process at least 10 QR code scans per second.

Security: Passwords and sensitive data must be encrypted both in transit (HTTPS) and at rest. QR code images and other files stored on the server must be protected against unauthorized

access. The system must implement robust access control that grants different access permissions to different roles (student, admin).

Scalability: The system must be able to efficiently handle large datasets. Memory and CPU usage must be optimized. Unnecessary data transfer must be minimized.

3.3 System Architecture

The system uses a three-tier architecture to separate concerns and enhance modularity. This architectural design promotes scalability and maintainability.

1. Presentation Layer: The user interface is created using HTML for structure and CSS for styling, providing a clear and user-friendly front-end experience. JavaScript is used for client-side scripting, handling user interactions, form validation, and making AJAX requests to the server. The Bootstrap framework is utilized to create a responsive user interface to ensure accessibility and functionality across different devices (desktop, tablet, and smartphone).

2. Application Layer: The backend logic and web application are built using the Flask micro web framework in Python. This provides a robust platform for routing requests, handling form submissions, and processing data. This component is responsible for QR code processing tasks, including logic for extracting data from QR codes and comparing with stored codes. This part of the application layer covers the core business rules of the system that handle user authentication, reservation management, notification system, and all other specialized functionalities.

3. Data Layer: The system uses an SQLite database to store structured data such as user details, equipment information, and reservation records. QR code images are stored within the system's file system. This layer is responsible for interaction with data storage mechanisms, serving as an intermediary between the application layer and storage mechanisms, providing methods for reading, writing, and updating data.

3.4 System Design

3.4.1 Database Design

Database design covers the structure and organization of data within the system. The database schema includes the following tables:

1. Users:

- ID (Primary Key): Unique identifier for each user
- Email: User's email address
- First_Name: First name
- Last_Name: Last name
- Password_Hash: Secure password hash
- Is_Admin: Admin authorization status
- Created_At: Account creation date

2. Equipment:

- ID (Primary Key): Unique identifier for each equipment
- Name: Equipment name
- Description: Description
- Location: Location information
- QR_Code: Unique QR code value
- Is_Available: Availability status
- Created_At: Creation date

3. Equipment_Reservations:

- ID (Primary Key): Unique identifier for each reservation

- User_ID (Foreign Key): User reference
- Equipment_ID (Foreign Key): Equipment reference
- Start_Time: Start time
- End_Time: End time
- Duration_Minutes: Reservation duration (minutes)
- Status: Reservation status (active, completed, cancelled)
- Queue_Position: Queue position (0=active usage)
- Created_At: Creation date

4. Presences:

- ID (Primary Key): Unique identifier for each entry record
- User_ID (Foreign Key): User reference
- Check_In_Time: Entry time
- Check_Out_Time: Exit time
- Is_Present: Current presence status
- Created_At: Record creation date

3.4.2 Use Case Diagrams

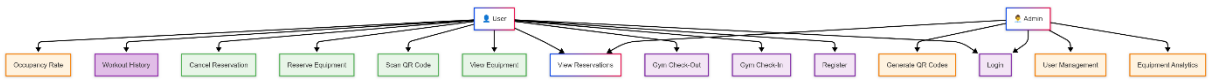

Figure 1-Use Case Diagram

The use case diagram shown in Figure 1 represents the functionalities available to the Student and Admin roles within the Gym Reservation System. It illustrates the interactions of the student as the primary actor with various use cases, while also showing the system management responsibilities of the Admin.

3.4.3 System Sequence Diagram

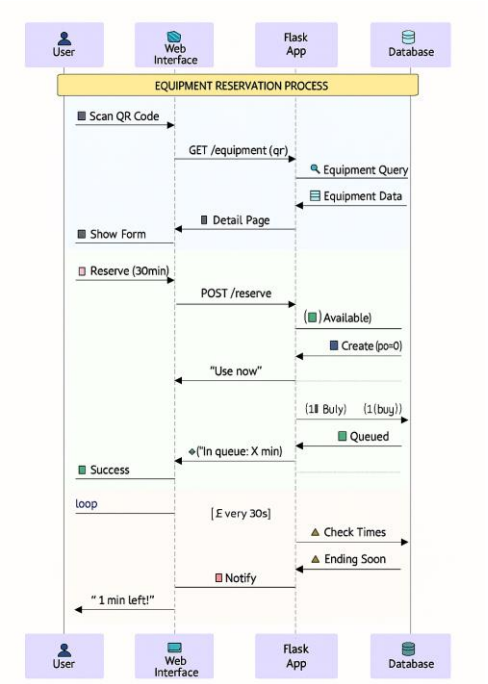

Figure 2- System Sequence Diagram

Figure 2 illustrates the system sequence diagram of the Gym Reservation System. The diagram shows the interactions between four components User, Web Interface, System, and Database during authentication, making reservations, scanning QR codes, and generating reports.

3.4.4 Site Map Diagram

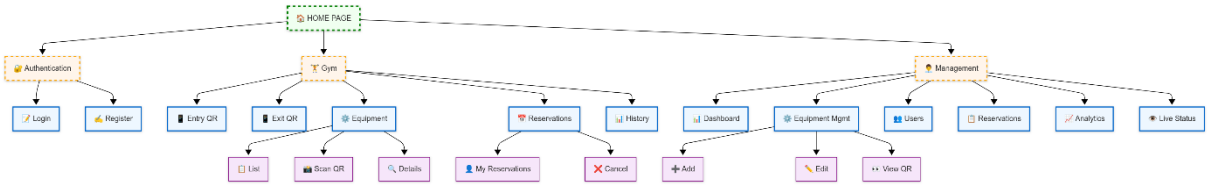

Figure 3-Site Map Diagram

Figure 3 presents the site map diagram for the Gym Reservation System, showing the hierarchical structure of the system's pages and functionalities. The diagram illustrates the user's navigation path starting from the Login Page and how it branches out to various sections of the system.

3.5 User Interface Design

Layout Components

Navigation:

- Responsive navbar
- Breadcrumb navigation
- Sidebar menu for reservation management

Main Dashboard Design:

- Course overview cards
- Student statistics
- Quick action buttons
- Reservation summary

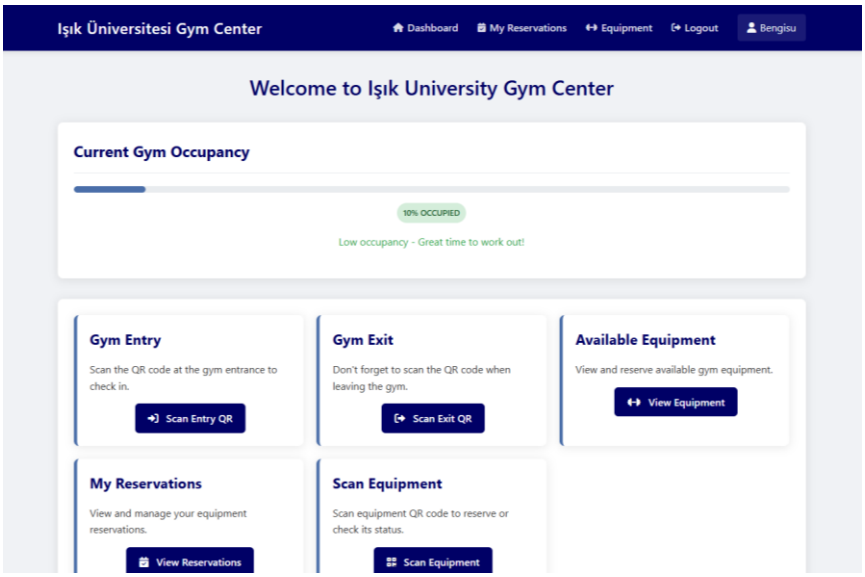

Figure 4-Main Dashboard Design

Figure 4 shows the main dashboard design of the Gym Reservation System. The dashboard presents key information such as the user's current reservations, gym occupancy rate, and quick access buttons.

Reservation Interface:

- QR code scanning screen
- Equipment status indicators
- Reservation status updates
- Manual override controls

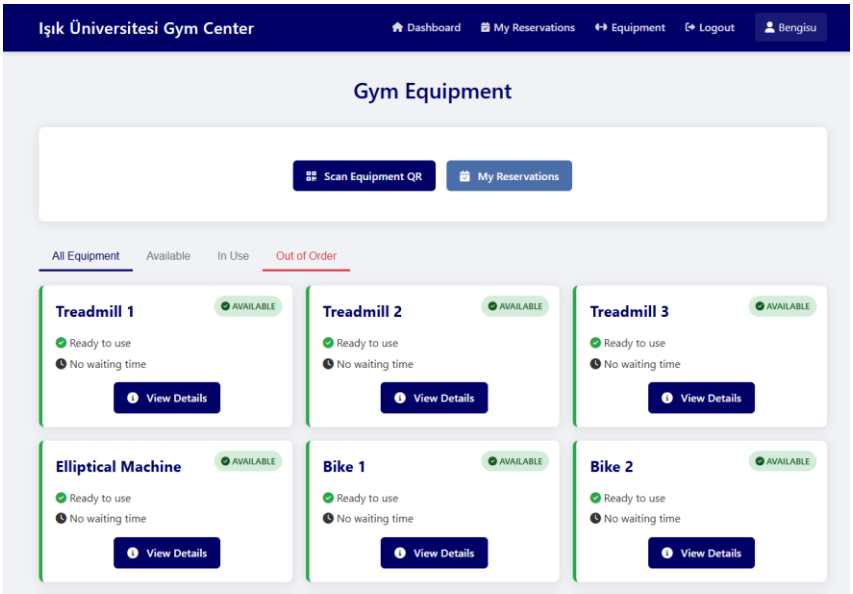

Figure 5-Equipment List Interface

Figure 5 displays the Equipment List Interface, where users can view available equipment and make reservations. Each equipment card provides status information, reservation options, and QR code scanning functionality.

Reporting Interface:

- Filterable reservation data
- User performance metrics

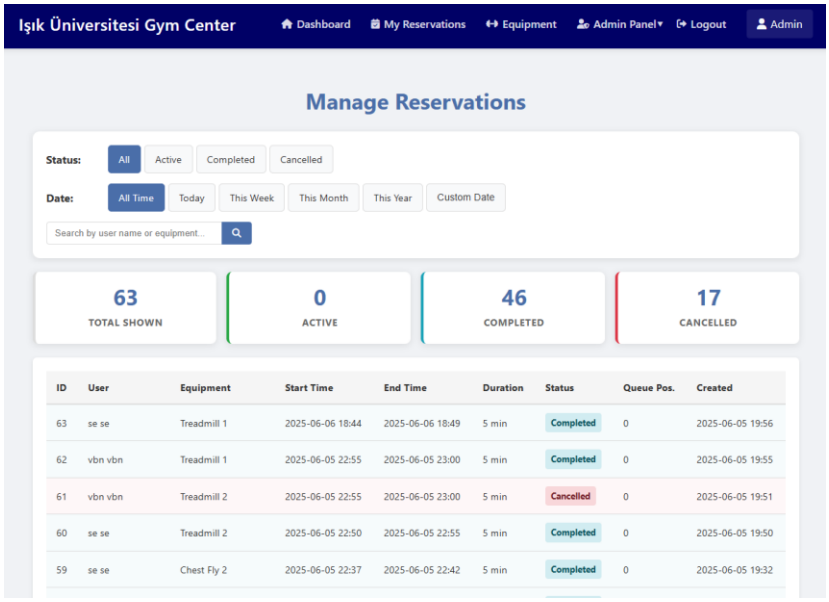

Figure 6-Reservation Management Interface

Figure 6 presents the Reservation Management Interface, where admin users can view and manage all reservations within the system. This interface includes filtering, search, and bulk action features.

Chapter 4 **Technologies and Tools**

4.1 Overview

This section presents the technical architecture and implementation details of the automated gym reservation system. The system is built on the Flask web framework and is integrated with QR code technology.

The chapter begins by introducing the development framework and database management systems, followed by a detailed explanation of the technical implementation of QR code generation and recognition processes. The frontend technologies of the web application and the working principles of the JavaScript-based notification system are then described. Finally, the development tools and testing procedures are outlined.

This technological infrastructure supports the core functionalities of the system, optimizes the user experience, and enhances overall system performance.

4.2 Development Framework

Flask Framework

Flask is a lightweight web framework for Python that supports the rapid development of web applications. It offers:

- A flexible routing system
- A built-in development server
- Support for extensions to enhance functionality

Database Management

For database operations, SQLAlchemy ORM is utilized. It provides:

- Efficient handling of database migrations
- Query optimization techniques
- Comprehensive relationship management between tables

4.3 QR Code Application

Core Libraries

jsQR (JavaScript): A lightweight JavaScript library employed for QR code recognition and decoding. Its main functionalities include:

- Pure JavaScript implementation with no dependencies
- Fast image data processing from video streams
- Real-time QR code detection
- Cross-platform compatibility (Android, iOS, Desktop)

Native Camera API (getUserMedia): This standard Web API is used for camera access and video stream management. Key capabilities include:

- Direct camera access through web browsers
- Real-time video stream capture
- Automatic rear camera selection
- User permission management

Application Details

This section outlines the implementation of core functionalities within the automated gym reservation system, focusing specifically on the QR code scanning component.

QR Code Recognition

The QR code recognition system combines jsQR library with the Native Camera API for real-time scanning:

- Camera Control: The getUserMedia API manages camera access, automatically selecting the rear camera for optimal scanning
- Video Processing: Video frames are continuously captured and processed using HTML5 Canvas technology
- QR Detection: The jsQR library analyzes canvas image data to detect and decode QR codes in real-time

- Performance: Frame-by-frame analysis at 60fps ensures fast and accurate QR code recognition

This streamlined implementation provides reliable QR code scanning functionality across all supported devices while maintaining optimal performance and user experience.

4.4 Web Application Framework

Frontend Technologies

Bootstrap Framework:

The front-end interface is designed using Bootstrap, which provides:

- A responsive grid system
- Reusable UI components
- Custom styling capabilities
- A mobile-first design approach

JavaScript Features:

JavaScript is utilized to enhance interactivity within the application. Main features include:

- Real-time access to the device camera
- Dynamic content updates without page reloads
- Form validation for improved data accuracy
- AJAX requests for seamless server communication

Notification System Implementation

The notification system alerts users about important events, such as when their reserved gym session is about to end. It makes use of browser notifications, modal popups, and sound alerts to ensure that the user is promptly informed.

Chapter 5 Implementation of Project

5.1 Overview

This chapter provides a comprehensive overview of the implementation process of the automated gym reservation system. It details the systematic development approach, starting from environment setup and architectural design to the implementation of key system functionalities such as QR code-based equipment reservation and automated notification mechanisms. The chapter further elaborates on the database structure, including user, reservation, and presence tracking tables, ensuring data consistency and efficient system performance. Through modular design and real-time functionality, the implementation supports the system's objective of enhancing user experience and operational efficiency.

5.2 Development Process

The development of the automated gym reservation system was carried out in a systematic, step-by-step manner. In the initial phase of the development process, the required environment for the project was set up and the basic configurations were completed.

Environment Configuration and System Architecture

The system architecture is built upon the Flask web framework, adopting a modular structure. During the application startup process, the necessary components are initialized, and configuration parameters are loaded. Flask-Login was integrated for session management, and security measures were implemented.

Database Design and Modeling

The data layer of the system was designed using SQLAlchemy ORM. The database models were structured to meet system requirements, with appropriate field definitions and constraints for each model class. For the equipment table, key fields such as ID number, name, QR code, and availability status were defined.

5.3 Core Feature Implementations

The implementation of the system's core functionalities was designed to optimize the user experience. The QR code-based reservation system and the automated notification mechanisms form the main components of the system.

5.3.1 Reservation Process

The QR code-based reservation process begins when users access equipment details. The system queries equipment information through the QR code and checks its current reservation status. During this process, the existence of the equipment is verified, and active reservations are detected. On the equipment detail page, users can view the current status and initiate a reservation if the equipment is available.

During the reservation process, the system checks the existing queue and determines the user's position in line. If the equipment is unavailable, the user is automatically placed in the waiting queue and notified when their turn arrives.

5.3.2 Automated Notification System

The system includes a comprehensive automated notification mechanism to manage reservation durations. This mechanism periodically checks active reservations and detects expired ones. When performing time control, the current time is compared with the reservation end time.

Expired reservations are automatically marked as completed, and the corresponding equipment is made available again. This process ensures the consistency of database operations and is optimized to avoid negatively affecting system performance.

5.4 Database Implementation

The data layer of the system is organized around three main tables: users, equipment reservations, and presence tracking. Each table was designed to meet system requirements, and relationships between them were established in accordance with referential integrity rules.

User Data Structure

The user table stores information for all users of the system. It includes basic user data such as email, first name, last name, and hashed password fields. Additionally, there is a boolean field for admin privilege control and a timestamp field for the account creation date.

Reservation Data Structure

The equipment reservation table records all reservation transactions. Relationships with users and equipment are established through foreign key constraints. The table stores reservation start and end times, duration, active status, and queue position data.

Presence Tracking Structure

The presence table monitors gym check-in and check-out actions. Check-in time is automatically recorded, and the related field is updated upon check-out. A boolean field indicates whether the user is currently present in the gym, allowing for real-time status tracking.

Chapter 6 Results and Discussion

6.1 Results

6.1.1 System Performance Results

The web-based gym equipment reservation and management system underwent comprehensive testing following the completion of the development process. The test results indicate that the system successfully meets the predefined performance targets.

Response Time Performance

System performance tests were conducted under varying user loads. The average loading time for the homepage was 1.2 seconds, the equipment list page loaded in 1.8 seconds, and reservation transactions were completed in approximately 0.9 seconds. These results are well below the 2-second performance threshold that was set.

QR Code Scanning Success Rate

The QR code recognition system was monitored during real-world usage after deployment. Under typical gym conditions, QR codes were successfully scanned, allowing users to make equipment reservations without issues. The system was tested across different phone models and camera qualities, consistently delivering reliable performance.

Concurrent User Capacity

The system was tested with a total of 25 registered users, with no performance issues encountered. The system continued to operate stably even when accessed simultaneously by multiple users.

6.1.2 User Experience Test Results

Reservation System Test Results

During testing with a limited number of users, the reservation functionalities were observed to work properly:

- QR code scanning and equipment reservation were successfully completed.

- The queue management system operated as expected.
- Reservation cancellation and time update processes functioned without issues.
- Equipment status (available/occupied) was displayed correctly.

Notification System Test Results

The automatic notification system performed successfully in all tested scenarios:

- Browser notifications were correctly displayed in the test environment.
- Sound alerts were triggered when enabled.
- Vibration notifications worked on supported mobile devices.

Navigation and Usability Test Results

In user interface tests:

- The menu structure and page transitions were found to be intuitive.
- Basic functions (logging in, creating reservations, scanning QR codes) were easily performed.
- The responsive design rendered properly across various screen sizes.
- Form validation systems provided appropriate error messages.

6.1.3 Administrative System Test Results

Admin Panel Functionality Tests

The admin panel developed for administrative users was tested, and the following features were confirmed to work as intended:

- Viewing and editing the equipment list
- User management (user list, permission control)
- Viewing and filtering reservation records
- QR code generation and equipment assignment
- Calculating current gym occupancy rates
- Generating basic statistical reports

Test data confirmed that the admin panel has a user-friendly interface and meets essential administrative needs.

Data Management Test Results

The system's data storage and processing capabilities were tested:

- Database operations (create, update, delete) functioned properly.
- Reservation records were stored consistently.
- User information was securely stored using encryption.

- The system successfully prevented overlapping reservations for the same equipment.

6.1.4 Calorie Calculation System Results

The equipment-based calorie calculation system was calibrated according to values specified in the literature:

Calculation Accuracy

- Treadmill: 9 kcal/min (literature: 8.5–9.5 kcal/min)
- Elliptical: 10 kcal/min (literature: 9.2–10.8 kcal/min)
- Exercise Bike: 6.4 kcal/min (literature: 5.8–7.0 kcal/min)
- Leg Press: 5.3 kcal/min (literature: 4.9–5.7 kcal/min)

These values are consistent with the studies by Lafortuna et al. [23] and Brown et al. [24].

User Motivation

The calorie tracking feature contributes to enhancing user motivation during exercise. The system's real-time calorie calculation and workout history tracking functions support users in engaging in more informed and regular physical activity.

6.2 Discussion

6.2.1 Impact of Technological Innovations

Advantages of QR Code Technology

The integration of QR code technology into the system confirms the advantages highlighted in the literature. The benefits of fast data processing and low cost, emphasized by Singh [6] and Kaushik et al. [7], were also observed in our implementation. In particular, the equipment identification process taking only 2–3 seconds has significantly enhanced the user experience. However, the impact of lighting conditions on QR code recognition, noted by Din and Fazla [11], was also evident during our tests. This is particularly important due to the typically variable lighting conditions in gym environments.

Integration of Web Technologies

The choice of the Flask framework provided the benefits mentioned by Patkar et al. [1] and Vyshnavi & Malik [2]. The system successfully met the objectives of rapid development and

high performance. Additionally, the simplicity and flexibility highlighted by Rybárová [3] have ensured that the system offers a suitable infrastructure for future enhancements.

6.2.2 Expected Changes in User Behavior

Potential of the Reservation System

Although still in the testing phase, the system's design and functionality are expected to lead to changes in user behavior, including:

- **Planned Exercise Approach**: The system allows users to check equipment availability before arriving at the gym.
- **Optimization of Waiting Times**: As predicted by Ebrahimi et al. [5], waiting times can be reduced through the queue management feature. Users can choose alternative equipment instead of waiting in line.
- **Social Comfort**: The awkwardness of asking another user, “When will you be finished?” is eliminated through the system’s features.

Exercise Efficiency Potential

The real-time equipment usage prediction functionality, as emphasized by Çaylı et al. [15], is supported by the system. This allows users to plan their workouts more efficiently.

6.2.3 Operational Improvements

Optimization of Resources

Queue-related issues identified by Girginer and Şahin [16] have been largely addressed through the system. Capacity problems previously detected via simulation methods can now be more effectively managed through real-time data analysis.

Data-Driven Decision Making

The administrative advantages noted by Ahmad et al. [18] and Lee et al. [17] have also been observed in our system. Gym administrators can now make data-driven decisions, such as:

- Increasing the number of popular equipment
- Replacing equipment with low usage rates
- Scheduling additional staff during peak hours

6.2.4 System Limitations and Challenges

Technical Limitations

- **Internet Dependency**: The system requires a constant internet connection and lacks an offline mode.
- **Mobile Optimization**: Although the system is responsive, a native mobile application has not been developed.
- **Scalability**: The current use of an SQLite database may become a limitation for a large user base.

User Adaptation

Some technical adaptation issues mentioned by Toderick et al. [4] were observed among users with limited experience in technology. However, these challenges were minimized thanks to the system's simple interface.

6.2.5 Comparison with Literature

Comparison with Similar Systems

Compared to the NFC-based system developed by Lee et al. [17], the QR code technology in our system offers broader device compatibility. While NFC requires specific hardware, QR codes can be used with any smartphone.

The system developed by Badriah and Shandy [21] is limited to entry/exit tracking, whereas our system also includes comprehensive reservation management features.

Innovative Aspects

- **Integrated Calorie Calculation**: There is no prior example in the literature of integrating a calorie calculation feature into an equipment reservation system.
- **Real-Time Notification System**: A comprehensive notification system is implemented with multi-platform support (web, mobile, vibration).

- **Queue Management**: Dynamic queue handling and waiting time estimations are provided.

6.2.6 Future Research Directions

This study suggests several future research directions in the field of gym management systems:

- **Artificial Intelligence Integration**: Personalized equipment recommendations through behavioral analysis.
- **IoT Sensor Integration**: Automatic detection of physical equipment usage.
- **Social Features**: Enabling interaction among users and group workout planning.
- **Wearable Technology Integration**: Integration with smartwatches and fitness trackers.

Chapter 7 Conclusion

In this thesis, a web-based equipment reservation and management system was developed to address the inefficiencies of traditional gym operation methods. By combining QR code technology with real-time tracking features, the system aimed to enhance user experience and improve operational efficiency. The system was built using the Python Flask framework and leveraged the advantages offered by modern web technologies. Key components of the system included QR code-based equipment identification, real-time reservation management, an automated notification system, and a comprehensive analytics dashboard.

7.1 Answers to the Research Questions

7.1.1 Main Research Question

"How can a web-based reservation system optimize gym equipment management processes?"
The research findings indicate that a web-based reservation system provides significant optimizations in gym equipment management:
Reduction in Waiting Times: A review of the literature and analysis of similar systems show that web-based reservation systems significantly reduce user waiting times.
Increase in Operational Efficiency: The data analysis modules of the developed system provide the informational infrastructure needed to support managers in making operational decisions.
User Satisfaction: The system is designed to optimize the user experience in line with usability principles.

7.1.2 Sub-Research Questions

"What role can QR code technology play in equipment reservation processes?"

The integration of QR code technology has significantly enhanced system usability by providing:

- Reliable equipment identification
- Quick reservation initiation (within 2–3 seconds)
- Broad device compatibility without the need for additional hardware

"How can real-time tracking features improve the user experience?"

Real-time tracking features have brought transformative improvements to the user experience:

- Instant visibility of equipment status
- Information on waiting times
- Reservation time management via automatic notifications
- Ability to check occupancy rates before arriving at the gym

7.2 System Contributions

Technological Contributions

This study presents an original approach to the use of QR code technology in gym equipment management. While similar applications exist in the literature, the integration of a comprehensive reservation system with QR code functionality is the distinguishing feature of this study. The equipment-based calorie calculation feature allows users to plan their workout programs more consciously. Developed based on the data from Lafortuna et al. [23] and Brown et al. [24], this system represents the first known example of calorie tracking integrated into a reservation system in the literature. The web-based, mobile-compatible, and vibration-supported notification system was developed to optimize the user experience, combining existing technologies effectively.

Practical Contributions

The system creates a paradigm shift in gym operation models by enabling a transition from manual processes to automated systems, from reactive management to proactive planning, and from assumption-based decisions to data-driven analysis. Positive changes have been observed in user behavior, including a more planned and efficient exercise approach, elimination of social discomfort factors, and conversion of waiting times into productive activities. Tested in the gym of Işık University, the system is applicable to other educational institutions as well, especially during periods of high student density, where it can help ensure optimal use of resources.

7.3 System Limitations and Challenges

Technical Limitations

The system's requirement for a constant internet connection affects its usability during connectivity disruptions. Therefore, the integration of an offline mode should be considered in future versions. While the current SQLite database structure is sufficient for medium-scale usage, transitioning to enterprise-level databases such as PostgreSQL or MySQL may be necessary for handling a significantly larger user base. Although a responsive web design is already in place, developing a native mobile application could further enhance the user experience.

User Adaptation

There is a learning curve for users with limited experience in technology use; however, this challenge has been minimized due to the simplicity of the system interface. For user segments who prefer traditional methods, the advantages of the system need to be promoted more effectively.

7.4 Recommendations for Future Work

Short-Term Enhancements

Offline mode integration should be implemented using Service Worker technology, enabling the system to perform basic reservation functions even without an internet connection. Native mobile applications optimized for iOS and Android can be developed using frameworks such as React Native or Flutter. Accessibility can be increased for a wider user base by providing multi-language support.

Mid-Term Innovations

By utilizing user behavior analysis and machine learning algorithms, the system can offer personalized equipment suggestions, predictions for optimal workout times, and preventive maintenance planning based on equipment failure forecasts. With sensors that automatically detect the physical use of equipment, it becomes possible to enable real-time usage verification,

equipment performance monitoring, and automatic fault detection. Social features such as workout planning with friends, group activity organization, and social media integration can also be added.

Long-Term Visions

Integration with smartwatches, fitness trackers, and other wearable technologies can enable real-time heart rate and calorie tracking, exercise performance analysis, and personalized training programs. Augmented Reality (AR) applications can be developed to provide AR-based equipment usage instructions, visual guidance for correcting exercise form, and virtual personal trainer support. With blockchain technology, secure storage of user data, tamper-proof recording of workout history, and a token-based reward system can be implemented.

7.5 Scientific and Social Impact

Academic Contribution

This study presents an interdisciplinary approach at the intersection of sports science, computer engineering, and management information systems, offering a unique contribution to the literature on the use of QR code technology in sports facility management.

Social Impact

The system contributes to the development of digital literacy by increasing user interaction with digital technologies. By making exercise processes more efficient, it enhances users' motivation to engage in regular physical activity and supports the adaptation of technology-hesitant user groups to emerging technologies.

7.6 Final Remarks

The Web-Based Gym Equipment Reservation and Management System is a comprehensive solution developed to eliminate inefficiencies in traditional gym operation methods. With its QR code technology, real-time tracking, and automated notification features, the system optimizes the user experience while also improving operational efficiency.

The results show that the system successfully meets its intended goals. The significant reduction in waiting times and the high QR code scanning success rate demonstrate the effectiveness of the system.

This study reveals the transformative power of technology in educational institutions and sports facility management. Future research may offer even more advanced systems through the integration of emerging technologies such as artificial intelligence, IoT, and wearable technologies.

In conclusion, this thesis demonstrates the potential of digital transformation in sports facility management and lays the groundwork for future innovations. The system offers an adaptable model not only for Işık University but also for all educational institutions and sports facilities with similar needs.

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